SERUM URIC ACID AND CHOLESTEROL VARIABILITY: A COMPREHENSIVE VIEW OF UNDERWATER DEMOLITION TEAM TRAINING

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Serum Uric Acid and Cholesterol Variability

A Comprehensive View of Underwater Demolition Team Training

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One-third (32 men) of a Navy Underwater Demolition Team training class was investigated by psychological assessment and serum uric acid and cholesterol determinations three times a week until they either withdrew from training or graduated. In general, significant elevations in serum uric acid levels occurred when trainees were eagerly taking on arduous activities with an optimistic attitude and determination to succeed. Significant elevations in serum cholesterol levels were seen in training situations in which the men felt overburdened by environmental variables, when they were relatively physically inactive, and, for selected individuals, when they failed portions of the training course.

Within the past decade it has been documented that a wide range of serum cholesterol concentrations is displayed in humans, and within the past few years similar data have been presented for serum uric acid.[1-5] It was believed earlier that these two serum fractions were remarkably stable except in persons with metabolic diseases such as gout or hypercholesterolemia.[6-8] Following many studies demonstrating the influence of various constitutional factors on these two serum fractions, it was found that certain psychological and behavioral variables also correlated strongly with elevated serum cholesterol and uric acid levels.[2,9-13]

Psychological, social, and behavioral variables which appear to correlate highly with elevated levels of serum uric acid include both relatively stable parameters such as social class, and temporary phenomena such as psychosocial stresses.[2,9-14] Long-term as well as transient elevations in uric acid levels have been noted to coincide with achievement-oriented behavior.[9-12] The individual with an elevated serum uric acid level has been described as one who attacks current environmental demands with zest and aptitude. He characteristically performs well, and often attains leadership positions.[9-11,13] He does not seem to be unduly put-upon by often substantial life demands; indeed, he appears to thrive on them.[10,13]

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Certain psychological and behavioral variables appear to correlate with elevations in serum cholesterol concentration.[1,7,15-20] The particular kinds of psychosocial conflict have not appeared to be as important as the indivdual's interpretation of them and how he sets about their resolution.[18-21] Often, the individual describes himself as all but inundated by situational demands.[7,19,20] He attempts to overcome life demands by conscientiousness, perseverance, and time-conscious hurrying.[7,16-24]

There is some overlap in the descriptions of the psychological and behavioral characteristics of persons with high serum uric acid concentrations and persons with high cholesterol concentrations; for example, they both have been described as hard-working and often successful. It appears that a crucial area of differentiation between the subject with a high serum uric acid level and the one with an elevated serum cholesterol concentration is in how the individual *perceives* his current life situation. Persons with high serum uric acid concentrations seem to view current life stresses as enjoyable challenges. Individuals with high concentrations of cholesterol, on the other hand, appear to perceive current life stresses as a sizeable burden under which they must successfully bear up.[7,10,14,16,17]

These two biochemical correlates of physical and psychological stress were studied in a class of US Navy Underwater Demolition Team (UDT) trainees. The physical demands and psychological pressures exerted on this particular group of young men have been outlined previously.[14] Few groups of men anywhere undergo a more rigorous and, in all senses of the word, stressful four months of training than do these frogmen. Therefore, the striking variability of serum uric acid and cholesterol levels presented in this communication may well be replicable only in men operating under similarly arduous conditions.

Materials and Methods

A random sample of UDT trainees was obtained prior to the start of the course by selecting every third name from an alphabetical roster of a class of slightly less than 100 men. The resulting sample,

32 men, was then observed throughout their training until they either dropped from the course or successfully graduated at the end of four months.

Blood samples (10 cc) were collected from the subjects three times a week for the first four weeks. During the fifth week, "hell week," blood samples were taken on four consecutive days. During the sixth through the tenth weeks of the course, blood samples were taken twice a week. The group was then arbitrarily divided in two by the instructors. The men remaining in the study by the tenth week had their diving training either from the 11th through the 13th weeks or from the 14th through the 16th weeks of training. While approximately half of these men underwent diving training, the others were learning demolition techniques. No blood samples were collected during the demolition phase of training because of logistic difficulties in the field. Therefore, serum data were obtained for the sample as a whole from the first through the tenth weeks of training; approximately half of the men contributed further data from the 11th through the 13th weeks, and the remainder of the sample provided final data from the 14th through the 16th weeks of the course.

All biochemical determinations were performed in our research laboratory. Serum cholesterol determinations were done by the method of Clark et al,[25] with an error in measurement of less than ±3%. Serum uric acid concentration was determined by the method of Liddle et al,[26] with an error of measurement of ±5%. All blood samples were fasting samples and were gathered from 5:30 AM to 6 AM. The serum was immediately separated and frozen until analysis. Statistical differences in the biochemical measurements at the 0.05 level or less were considered significant.

Behavioral data were obtained both as impressions of the men's emotional states and reactions to training and were gathered by the medical corpsmen at the time of the blood drawings, and at periodic conferences about the trainees with class instructors. Each time blood samples were taken the men completed a standardized mood-and-attitude questionnaire. In addition, each trainee completed a military version of the Schedule of Recent Experience (SRE), which measured the amount of life change for each subject in the years prior to UDT training.[27]

Results

Twenty of the 32 trainees selected completed the UDT training program. The percent of men withdrawing from the program (37%) in the sample was close to the overall percent withdrawing from the entire class (31%). During the first two to three weeks of training, serum uric acid levels were lower and serum cholesterol values were higher for the group of men in the sample who withdrew from training than were the values for the group of men who completed the course. However, these differences were not statistically significant.

On the mood-and-attitude assessment questionnaire given each time blood samples were taken, the men who withdrew from the program registered more complaints about the training program and indicated more psychophysiologic symptoms than did the men who completed the course. On the SRE questionnaire, the men who withdrew from UDT training primarily for medical reasons registered an average of 422 life-change units each for the year prior to training, while the men who completed the program averaged 297 life-change units each during the same period. The difference between these two means was in the predicted direction but not statistically significant.

Serum Uric Acid and Cholesterol Changes During the First Two Months of Training.—The 20 men who completed the UDT program trained together for the first two months of the course. Figures 1 and 2 indicate the means and standard errors on each day blood samples were collected for uric acid and cholesterol determinations, respectively. As in a previous pilot study, the highest serum uric acid concentration was found during the first week of training. A further similarity between the data from this sample and the pilot study was that on the first day of "hell week," mean serum uric acid concentration was relatively low; the only lower value in this study was the one taken after a relatively easy week of training following "hell week."

Figure 1 shows seven peaks in serum uric acid concentration during the first two months of training. Only the peaks on Jan 20 and 25 were not statistically significant elevations when compared to the previous troughs. Table 1 presents these data in detail. Statistically significant rises in serum uric acid concentration occurred on days when the subjects were taking on new, challenging, and often physically demanding UDT training activities. Significant falls in serum uric acid levels coincided with days of prolonged, unpleasant physical activity or times when the men were allowed an easy schedule.

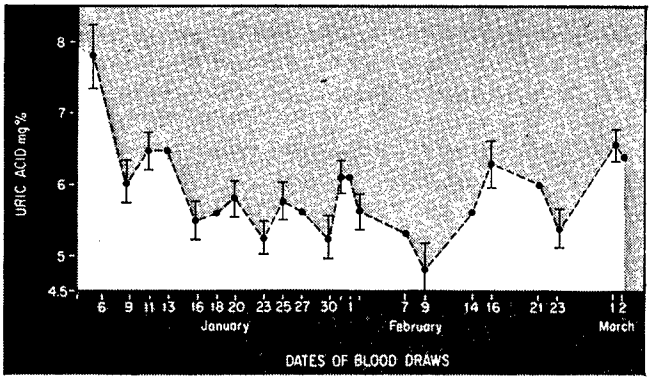
Considerable variability was also seen in the mean serum cholesterol data. As in the pilot study, a significant rise in mean cholesterol level occurred during "hell week." Figure 2 indicates four other peaks in cholesterol concentration which occurred during the first two months of training. Only the peak on Jan 9 was not statistically significantly higher than the previous trough. Table 2 presents these data in detail. Serum cholesterol concentration changed significantly on many of the same days as did serum uric acid concentration; often, however, in opposite directions. Significant peaks in serum cholesterol concentration coincided with prolonged, unpleasant, anxiety-provoking, and often body-chilling activities. Declines in mean serum cholesterol level occurred when the trainees were physically active but not under undue challenge from difficult course material.

On closer analysis, UDT activities were found to

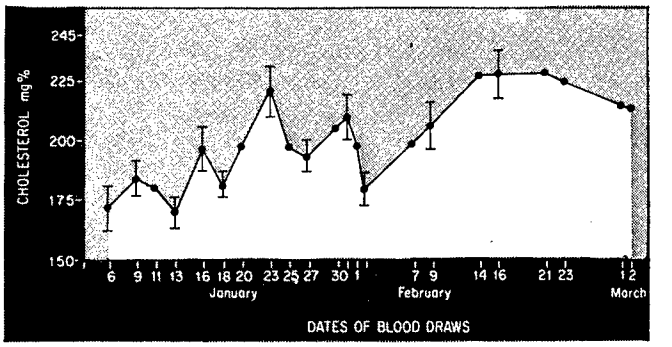
be nearly coincident with significant changes in serum uric acid and cholesterol concentration during the first two months of training. During the first week of training, the men were enthusiastic, alert, and generally confident of their abilities; serum uric acid was at its highest level and serum cholesterol near its lowest. By the second week, distance running covering several miles a day and distance swimming began. Most of the men were better runners than swimmers during the early part of the course, and serum cholesterol levels showed a significant rise at the start of the distance swimming. After an abrupt drop in serum uric acid concentration following the first week of training, a significant rise occurred coincidentally with the buildup in distance swims. A very significant fall in uric acid levels and a substantial rise in cholesterol levels occurred on the day of the first ocean swim—a distance swim of 1 mi, without wet suit, in 56-F water. Most of the trainees had done little or no underwater diving previous to the start of the course, and the introduction of technical gear, such as the face mask during the third week, was met with overt anxiety by many trainees. At this time, serum cholesterol levels rose significantly higher than the previously elevated levels associated with the 1-mi ocean swim.

"Hell week," the fifth week of training for this class, was described in some detail in the pilot study.[14] The men were kept on the move for five days and nights and were allowed very little sleep. The prime objective of this week is to teach the trainees that no matter how tired they feel, they can always manage further effort if the need arises. On the first day of this week, mean serum uric acid concentration was relatively low. By the next day it had risen significantly, only to fall once more toward the end of the week. Serum cholesterol concentration similarly demonstrated a significant rise and fall during "hell week." The men's attitudes and behavior changed dramatically during this week. On the first day they saw the week as an enormous hurdle that they had to surmount, and they struggled to accomplish this end. By the second day the men generally realized that they could not possibly continue such a pace, and they began to economize their energies. At the end of the week their esprit de corps was low, and their tolerance for the grueling schedule had been depleted.

The following week the men were given a relatively easy schedule. At the end of this sixth week, serum uric acid was at its lowest mean concentration. The men also began classroom reconnaissance work, and many of the trainees found this to be quite difficult. Serum cholesterol levels rose significantly during this week. The highest peak in cholesterol concentration during the entire first two months of training, however, occurred with the introduction of swim fins and UDT weaponry during the seventh week. Serum uric acid approximated its highest concentration during this week as well. Besides the inherent anxiety in learning to handle



1. Group mean uric acid levels and standard errors for each day blood sample was taken during first two months of Underwater Demolition Team training.



2. Group mean cholesterol levels and standard errors for each day blood sample was taken during first two months of Underwater Demolition Team training.

weapons, many of the relatively good swimmers, as well as most of the poor ones, had difficulty in learning to swim with diving fins. Serum cholesterol levels remained high throughout the eighth week during which the men experienced helicopter drops and pickups. At the end of the second month, serum cholesterol concentrations fell concomitantly with the trainees' first night swim. Serum uric acid levels dropped during the helicopter maneuvers but rose sharply again by the time of the night problem.

Diving Training.—Following the first two months of training the sample of 20 UDT trainees was arbitrarily divided into two groups: group A went immediately into diving training while group B began demolition training. Groups A and B were comprised of subjects who demonstrated nearly equal degrees of variability of serum uric acid and cholesterol levels during the first two months of training. The two groups did not differ in any major demographic dimension. Therefore, the primary difference between the two groups was that group A took its diving training first.

Group A was composed of nine men who were described by their instructors as sorely in need of military discipline following their relatively lax previous month of training. These men were no less able than those in group B, but they needed constant harassment to bring them up to usual discipline standards. Figure 3 indicates that on two

Table 1.—Significant Changes in Mean Serum Urate Concentration and Concomitant UDT* Training Activities First Two Months of Training

Date	Mean (mg/100 cc)	No. of Men Sampled	Observation No.	Observations Compared	t†	Significance Level	UDT* Training Activity
Jan 6	7.78	11	1	...	...	...	Primarily physical training
Jan 9	6.05	19	2	2-1	−4.11	0.005	Distance swims of progressive length
Jan 11	6.54	20	3	3-2	2.67	0.01	Half-mile swims (heated pool)
Jan 13	6.46	20	4	...	...	...	Mile swim (heated pool)
Jan 16	5.53	20	5	5-3	−5.59	0.001	First ocean swim, 1 mi
Jan 23	5.21	20	8	8-5	−1.42	...	First swim with face mask (heated pool)
Jan 25	5.72	20	9	9-5	1.24	...	First ocean swim with face mask, 1 mi
Jan 30	5.23	20	11	11-9	−2.42	0.025	Start of "hell week"
Jan 31	6	18	12	12-11	4.43	0.001	Second day of "hell week"
Feb 2	5.59	20	14	14-12	−2.45	0.025	Fourth day of "hell week"
Feb 9	4.79	14	16	16-14	−2.95	0.01	First week of primarily classroom work
Feb 16	6.26	19	18	18-16	5.64	0.001	Introduction to swim fins and UDT* weapons
Feb 23	5.43	17	20	20-18	−3.8	0.001	First helicopter drop and pickup
March 1	6.46	20	21	21-20	5.12	0.001	First night swim

*UDT signifies Underwater Demolition Team.
†Significance levels were determined by the t-test for correlated means.

Table 2.—Significant Changes in Mean Cholesterol Concentration and Concomitant UDT* Training Activities First Two Months of Training

Date	Mean (mg/100 cc)	No. of Men Sampled	Observation No.	Observations Compared	t†	Significance Level	UDT* Training Activity
Jan 6	172	11	1	...	...	...	Primarily physical training
Jan 9	185	19	2	2-1	0.18	...	Distance swims of progressive length
Jan 11	183	20	3	...	...	...	Half-mile swims (heated pool)
Jan 13	171	20	4	4-2	−2.51	0.025	Mile swim (heated pool)
Jan 16	193	20	5	5-4	3.19	0.005	First ocean swim, 1 mi
Jan 23	218	20	8	8-5	3.24	0.005	First swim with face mask (heated pool)
Jan 25	197	20	9	9-8	−4.04	0.001	First ocean swim with face mask, 1 mi
Jan 30	206	20	11	...	...	...	Start of "hell week"
Jan 31	211	18	12	12-9	2.54	0.025	Second day of "hell week"
Feb 2	180	20	14	14-12	−6.01	0.001	Fourth day of "hell week"
Feb 9	206	15	16	16-14	5.69	0.001	First week of primarily classroom work
Feb 16	228	18	18	18-16	2.44	0.025	Introduction to swim fins and UDT* weapons
Feb 23	224	18	20	...	...	...	First helicopter drop and pickup
March 1	215	20	21	21-18	−1.91	0.05	First night swim

*UDT signifies Underwater Demolition Team.
†Significance levels were determined by the t-test for correlated means.

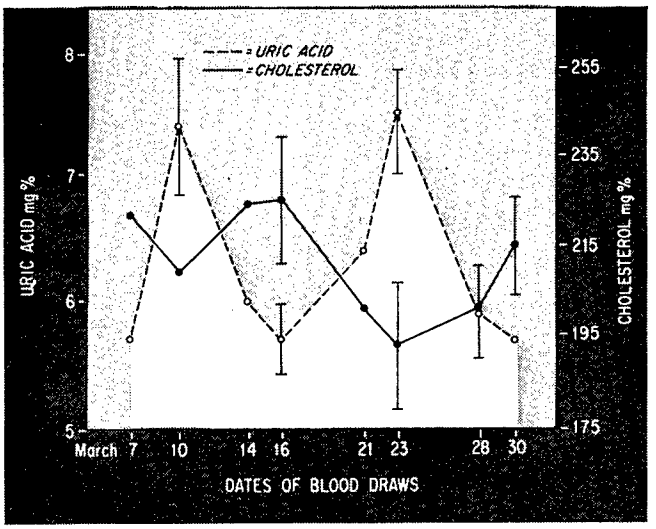
Table 3.—Serum Uric Acid and Cholesterol Variability for Diving Group A

Date	Mean (mg/100 cc)	No. of Men Sampled	Observation No.	Observations Compared	t*	Significance Level	UDT† Training Activity
				Uric Acid			
March 7	5.74	6	23	...	...	...	Classroom work
March 10	7.4	8	24	24-23	2.47	0.05	Introduction to scuba gear
March 16	5.71	5	26	26-24	−3.13	0.05	Night problem
March 23	7.48	8	28	28-26	5.46	0.01	Mine searching, long compass swim
March 28	5.87	5	29	29-28	−2.94	0.05	Long compass swims
March 30	5.73	9	30	30-29	−0.52	...	End of diving
				Cholesterol			
March 7	221	6	23	...	...	...	Classroom work
March 10	208	8	24	24-23	−1.91	...	Introduction to scuba gear
March 16	225	5	26	26-24	−0.61	...	Night problem
March 23	192	8	28	28-26	−2	...	Mine searching, long compass swim
March 28	202	5	29	29-28	3.02	0.01	Long compass swims
March 30	214	9	30	30-29	1.45	...	End of diving

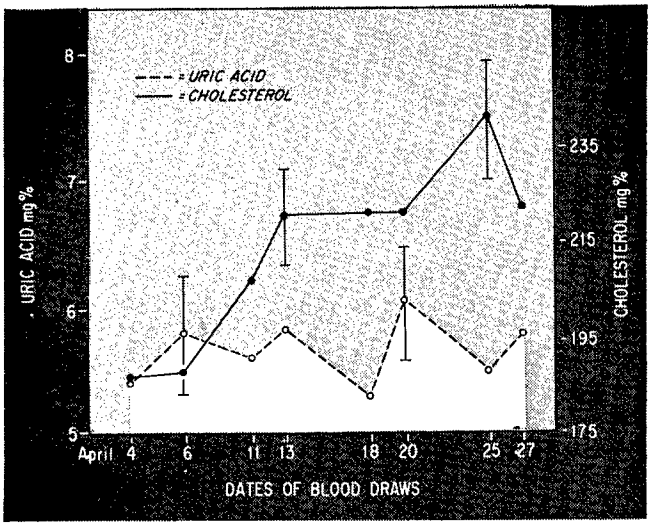
*Significance levels were determined by the t-test for correlated means.
†UDT indicates Underwater Demolition Team.

occasions during their diving training these men demonstrated statistically significant peaks in mean serum uric acid concentration. Table 3 shows that the first peak occurred concomitantly with the introduction of scuba (self contained underwater breathing apparatus) gear, and the second peak was coincident with the first in a series of final-exam compass and mine-searching swims. Figure 3 also indicates that on the days of mean serum uric acid peaks there were simultaneous but not statistically significant troughs in mean serum cholesterol values. Table 3 shows that a significant peak in cholesterol concentration occurred concomitantly with the first of the final-exam compass swims.

Group B, the remaining 11 subjects in the sample, came to diving training as a well-disciplined group after having completed a very exacting demolition-training schedule. However, the men realized they were near the end of the course and were noticeably less enthusiastic about UDT training than they were at the beginning. Figure 4 and Table 4 show that during the entire diving period for group B there was only one statistically significant change in mean serum uric acid concen-



3. Group A mean uric acid and cholesterol levels and standard errors for each day blood sample was taken during month of diving training.



4. Group B mean uric acid and cholesterol levels and standard errors for each day blood sample was taken during month of diving training.

Table 4.—Serum Uric Acid and Cholesterol Variability for Diving Group B

Date	Mean (mg/100 cc)	No. of Men Sampled	Observation No.	Observations Compared	t*	Significance Level	UDT† Training Activity
				Uric Acid			
April 4	5.57	10	31	...	...	...	Classroom work
April 6	5.82	11	32	32-31	0.65	...	Introduction to scuba gear
April 13	5.82	9	34	34-32	—0.19	...	Night problem
April 18	5.39	8	35	35-34	—1.47	...	Mine searching, long compass swim
April 20	6.05	9	36	36-35	1.02	...	Long compass swims
April 25	5.46	11	37	37-36	—2.44	0.025	End of diving
				Cholesterol			
April 4	189	10	31	...	...	...	Classroom work
April 6	188	11	32	32-31	1.07	...	Introduction to scuba gear
April 13	219	11	34	34-32	4.4	0.001	Night problem
April 18	222	11	35	35-34	0.2	...	Mine searching, long compass swim
April 20	222	9	36	36-35	—0.16	...	Long compass swims
April 25	242	11	37	37-36	1.12	...	End of diving

*Significance levels were determined by the t-test for correlated means.
†UDT indicates Underwater Demolition Team.

tration—a decrease at the end of the course, and they also indicate a significant peak in serum cholesterol concentration coincident with the night problem swim which tested the men's newly acquired diving skills with scuba. A progressive elevation in serum cholesterol concentration was seen for group B during the final diving exam long-compass swim. Three of these 11 trainees failed at least one of their final-exam swims.

Comment

The data from this investigation indicate that mean elevations in serum uric acid levels occurred coincidentally with eagerly accepted, arduous tasks (the beginning of training), with the introduction of new and challenging techniques (face mask, swim fins, weapons, first night swim, and scuba gear for group A), and with preparation for subsequent long-term grueling tasks (early in "hell week," the first of the final-exam compass swims for group A). The 12 men who withdrew from training had lesser elevations of uric acid at the beginning of UDT training than did the ultimately successful trainees. Individual trainees demonstrated substantial peaks in their serum uric acid levels when they were noted to be alert, attentive, eager for training, and trying hard to master course materials.

Little attention has been paid to the physical and psychological concomitants of low levels of serum uric acid. The mean data for the UDT trainees indicate that low serum uric acid concentrations were seen when the men were in situations requiring relatively little physical exercise (first week following "hell week"), in times of few new technical demands (periods following the introduction of face mask, fins, weapons, and scuba gear) and during periods when the men were quite anxious and literally at the mercy of external factors (the start of "hell week" and helicopter drops). Individual trainees who registered many complaints and physical symptoms during the early part of the training program and who ultimately dropped from the course demonstrated relatively low levels of serum uric acid. The individuals who managed to graduate but barely made it through their training rarely

showed an elevated serum uric acid level. Also the subjects who had particular difficulty in passing their final-exam compass swims demonstrated very low concomitant serum uric acid levels.

Mean serum cholesterol data suggest that significant elevations were seen in situations provocative of anxiety (introduction of face mask, swim fins, weapons, and scuba gear), during periods of relatively little physical exercise (classroom reconnaissance training, diving training), and during periods of learning new skills (classroom reconnaissance training, the middle of "hell week," early distance swimming with fins, and final-exam compass swims for group B). The trainees who withdrew from the course tended to have higher initial serum cholesterol levels than those trainees who graduated. Individuals who failed their final-exam compass swims and those who had marked difficulties with their swimming demonstrated large concomitant elevations in their serum cholesterol levels.

The mean cholesterol data during the first two months of training indicate that rugged physical exercise, without concomitant environmental stresses productive of feeling of anxiety or ineptitude or both, as was the case for the trainees during the first few weeks of the course, may be associated with low levels of serum cholesterol. Another time when mean serum cholesterol level was low was when the men approached physical exhaustion at the end of "hell week." Data from individual trainees indicate that when a man felt confident of his abilities during his training schedule and performed well, he simultaneously demonstrated a low serum cholesterol level.

Since all blood samples were taken prior to the start of the UDT activities for that day, the serum concentrations of uric acid and cholesterol seen were accounted for either by the trainees' anticipatory reactions to the day's schedule or by delayed body clearance of these serum fractions following the previous day's activities. Previous research suggests both these possibilities; each probably contributes to the observed variability. Estimations of these separate contributions are beyond the scope of this report.

In a future article, serum cortisol levels determined from the same blood samples taken in this study will be reported. We hope that with this added parameter an estimate of the degree of a trainee's difficulty with a particular phase of UDT training may be even more objectively identified. The intercorrelations of serum uric acid, cholesterol, and cortisol will be included in this future report.

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13. ABSTRACT

One-third of a Navy underwater demolition team training class (32 men) was investigated by thrice weekly psychological assessment and serum uric acid and cholesterol determinations until they either dropped from training or graduated. In general, significant elevations in serum uric acid occurred when trainees were eagerly taking on arduous activities with an optimistic attitude and determination to succeed. Significant elevations in serum cholesterol levels were seen in environmental variables, when they were relatively physically inactive, and for selected individuals, when they failed portions of the training course.

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